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Sensitivities of Selected Chemical Detectors

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Abstract

This document includes an assessment of the sensitivity of three chemical agent detectors. The Joint Chemical Agent Detector (JCAD), the Automatic Chemical Agent Detector Alarm (ACADA) and the AP2C detector made by the Proengin Corporation are the three detectors. The sensitivity of the detectors is compared to that needed to measure point concentrations and dosages of the chemicals and to determine the absence of the chemical agents.

KEYWORDS: Nuclear, Biological and Chemical (NBC), Performance Requirements of Chemical Detectors

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Executive Summary

The illustrations in this report show that, of the current and developing detectors, only the JCAD may have the needed sensitivity to assure that no hazard exists due to chemical warfare vapors. Depending upon the final and tested JCAD capabilities, the users may be able to use the JCAD to assure the absence of chemical agents after a decontamination process. If the JCAD meets its threshold requirement, then the JCAD pre-concentrator will have to collect vapors for eight hours to verify the absence of chemical agents. If the JCAD meets its objective sensitivity requirements, then the JCAD would verify the absence of the vapors in 15 minutes.

Section 1

Introduction

This document includes an assessment of the sensitivity of chemical detectors. The assessment compares the functional sensitivity of current detectors and developing detectors and contrasts these sensitivities with baseline chemical hazard levels.

This assessment helps answer questions related to the improved performance of the developing detectors, such as:

Will the developing detectors be able to assure that the chemical hazard is sufficiently low enough to remove protective equipment? If the JCAD meets its threshold requirements, then the JCAD will verify the "NONE" hazard levels for short exposure times. If the JCAD meets its objective requirements, then the JCAD will verify the "NONE" hazard levels at the concentration levels required for the eight hour time weighted average (TWA) guidelines.

- Can the developing detectors establish how clean the environment is? Since the JCAD measures both concentration and dosage, the JCAD will provide measures to verify the concentrations and hazard levels over its measurement range.
- For missions of different duration, what level of decontamination is desired and do the detectors provide insight to these levels? The graphs in this report provide insight into the detection capabilities of the detectors for various mission durations.
- Is there a safe concentration for any mission and what is it? Based upon the exposure guidelines, the lowest concentrations are associated with exposures of 1-14 days in an aircraft.

The assessment includes the identification of specification and requirements that could improve the description of the needed detection capabilities.

Section 2

Approach

Detection sensitivity requirements from the JCAD performance specification are used in this assessment as projected performance. The ACADA measured performance is used in this assessment. The vendor data sheets for the AP2C detector are also used in this assessment. These performances are compared to hazard levels for the chemical warfare agents.

In this report, these sensitivity requirements are illustrated by plotting the detection sensitivities on concentration verses time graphs. Each detector assessed is illustrated on these graphs. Standard human hazard levels are illustrated on the same graphs. Thus, the sensitivity performance levels of the detectors can be compared to the hazard levels.

Section 3

Hazard Levels

This section includes tables that illustrate the hazard level guidelines from Department of Defense reports.

In this section and throughout this document the following military abbreviations are used:

ACC	Hydrogen Cyanide
CK	Cyanogen Chloride
GA	Tabun
GB	Sarin
GD	Soman
GF	is not an abbreviation
HD	Distilled Mustard
HN3	Nitrogen Mustard
L	Lewisite
VX	is not an abbreviation

In Table 1, the single dose hazard levels are from the unclassified data in ERDC-SP-018, March 1994.

Table 1. Single Dose Hazard Levels, K_d

Hazard Levels	GA	GB	GD, GF	VX	HD
No observed affects (2-10 minute exposure in mg-min/m^3)	$\leq$0.05 (concentration is $\leq$0.005 mg/m^3 for 10 minute exposure; $\leq$0.025 mg/m^3 for 2 minute exposure)	$\leq$0.05 (concentration is $\leq$0.005 mg/m^3 for 10 minute exposure; $\leq$0.025 mg/m^3 for 2 minute exposure)	$\leq$0.02 (concentration is $\leq$0.002 mg/m^3 for 10 minute exposure; $\leq$0.01 mg/m^3 for 2 minute exposure)	$\leq$0.009 (concentration is $\leq$0.0009 mg/m^3 for 10 minute exposure; $\leq$0.0045 mg/m^3 for 2 minute exposure)	$\leq$2.5 (concentration is $\leq$0.25 mg/m^3 for 10 minute exposure; $\leq$1.25 mg/m^3 for 2 minute exposure)
Protect From Symptoms: Miosis, Conjunctivitis, Rhinorrhea, and Tightness in Chest (2-10 minute exposure in mg-min/m^3)	>0.05 & <0.5 concentration is >0.005 mg/m^3 for 10 minute exposure; <0.25 mg/m^3 for 2 minute exposure)	>0.05 & <0.5 concentration is >0.005 mg/m^3 for 10 minute exposure; <0.25 mg/m^3 for 2 minute exposure	>0.02 & <0.2 concentration is >0.002 mg/m^3 for 10 minute exposure; <0.1 mg/m^3 for 2 minute exposure)	>0.009 & <0.09 concentration is >0.0009 mg/m^3 for 10 minute exposure; <0.045 mg/m^3 for 2 minute exposure	>2.5 & <25 concentration is >0.25 mg/m^3 for 10 minute exposure; <12.5 mg/m^3 for 2 minute exposure
Mask - Protect lungs (2-10 minute exposure in mg-min/m^3)	$\geq$0.5 concentration is $\geq$0.05 mg/m^3 for 10 minute exposure; $\geq$0.25 mg/m^3 for 2 minute exposure	$\geq$0.5 concentration is $\geq$0.05 mg/m^3 for 10 minute exposure; $\geq$0.25 mg/m^3 for 2 minute exposure	$\geq$0.2 concentration is $\geq$0.02 mg/m^3 for 10 minute exposure; $\geq$0.1 mg/m^3 for 2 minute exposure	$\geq$0.09 concentration is $\geq$0.009 mg/m^3 for 10 minute exposure; $\geq$0.045 mg/m^3 for 2 minute exposure	$\geq$25 concentration is $\geq$2.5 mg/m^3 for 10 minute exposure; $\geq$12.5 mg/m^3 for 2 minute exposure
Suit – Protect Skin (30-50 minute exposure in mg-min/m^3)	$\geq$1000 concentration is $\geq$20 mg/m^3 for 50 minute exposure; $\geq$33 mg/m^3 for 30 minute exposure	$\geq$600 concentration is $\geq$12 mg/m^3 for 50 minute exposure; $\geq$20 mg/m^3 for 30 minute exposure	$\geq$150 concentration is $\geq$3 mg/m^3 for 50 minute exposure; $\geq$5 mg/m^3 for 30 minute exposure	$\geq$5 concentration is $\geq$0.1 mg/m^3 for 50 minute exposure; $\geq$0.17 mg/m^3 for 30 minute exposure	$\geq$25 concentration is $\geq$0.5 mg/m^3 for 50 minute exposure; $\geq$0.83 mg/m^3 for 30 minute exposure

Table 2 includes the correlated data from the summary of existing and recommended estimates from the ERDC-SP-018 data. Notice that the highest single dose hazard level in Table 1 is half of the recommended guidelines. Notice that the lowest single dose hazard level is ten times lower than the ocular or nasal vapor guidelines.

Table 2. Recommended Estimates at Ect_{50}

Hazard Levels	GA	GB	GD,GF	VX	HD
Ocular or Nasal Vapor (2-10 minute exposure in mg-min/m^3)	$\geq$0.5	$\geq$0.5	$\geq$0.2	$\geq$0.09	$\geq$25
Percutaneous vapor (30-50 minute exposure in mg-min/m^3)	$\geq$2000	$\geq$1200	$\geq$300	$\geq$10	$\geq$50

Table 3 includes the correlated data from the summary of existing and recommended guidelines from the *SHORT-TERM CHEMICAL EXPOSURE GUIDELINES FOR DEPLOYED MILITARY PERSONNEL*, U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE TG 230A, May 1999 Version. This data indicates the concentration levels at which the chemicals are safe for short time periods of 14 days or less. Table 3 includes the concentration data related to safe TWA concentrations for unmasked workers in an agent environment for eight hours. Table 3 includes the concentrations that are safe in any environment and the recommended upper boundary for three-day TWA concentrations for the general population. The eight-hour TWA (EhrTWA) concentrations, the three-day TWA concentrations and the no effect concentrations are from the unclassified Army Regulation 385-61, 28 February 1997. Of these, the unmasked agent worker EhrTWA concentrations are selected as the minimum effects concentrations. These values are plotted in the graphs as the upper boundary on the allowable concentrations of the agents. This is the goal level of the detectors, so they would be able to verify that the agents concentration is effectively gone.

Table 3. Minimum-Effects Concentrations

Concentration(mg/m^3)	**GA**	**GB**	**GD**	**VX**	**HD**	**L**
One to fourteen day, Military Air Guideline – Short Term, Ocular or Nasal Vapor 1-14 day exposure	0.00001	0.00001	0.000003	0.00003	0.003	
Unmasked Agent worker 8-hour Time Waited Average (TWA) in any work shift (The demonstration standard)	0.00003	0.0001	0.0001	0.00001	.003	.003
No Effects Concentrations in any environment	0.000003	0.000003	0.000003	0.000003		
General Population 3-day TWA	0.000003	0.000003	0.000003	0.000003	0.0001	0.003

Section 4

Generic Discussion of Measurements

There are various ways to measure the sensitivity of detectors. They are:

1. Measure the constant concentration of the agent at the lowest detection level of the instrument. The units of concentration are normally milligrams per cubic meter (mg/m^3) or particles per billion. The conversion between mg/m^3 and particles per billion depends upon the gas law, temperature, and pressure.
2. Measure the dosage that is detected by the instrument. Dosage is typically the integral of concentration over time. The units of dosage are normally milligram-minutes per cubic meter ($mg\text{-}min/m^3$). The JCAD is specified to measure dosage and compare these measurements to hazard levels and provide alerts. These hazard levels are called "single dose hazard levels." Notice that dosage measurements do not require that the concentration be at a constant level.
3. Measure the alert response time of the detector when the instrument is exposed to a constant concentration. This is typically called the "maximum alert response time at concentration." These response times are indicated as response time duration in seconds for constant concentrations in mg/m^3.

To compare the sensitivities of detectors, we chose to plot the detector performance on a concentration-time graph. Concentration measured at the lowest detection level is plotted on the vertical axis of the graph. Detection duration times are plotted along the horizontal axis. Constant dosage measurements are plotted along the lines determined by the following equation:

$$K_d = \text{Dosage} = \text{Concentration}(t) * \text{Time} \qquad (mg\text{-}min/m^3) \qquad [1]$$

The values for K_d are called "single dose hazard levels." These single dose hazard levels are specified for a specific hazard and for specific chemical agents. The exposure response times of the detector is plotted as a point in the graph. Each plotted point is labeled. Measurement responses from the same detector are indicated with a unique icon. The graphs have a legend that relates the icons with the data plotted in the graphs.

The single dose hazard levels are related to various observed affects upon humans. These special single dose hazard levels are as follows:

1. The level of concentration that has no observed affect over a 1-14 day period. This level is the Military Air Guideline-Short Term for ocular or nasal vapor. This level is plotted as the cut-off values for longer exposure time of the "NONE" hazard dosage

level. It is this "NONE" hazard dosage value that detectors should measure in an aircraft air controlled environment.

2. The level of concentration that has no observed affect over an eight-hour work shift for workers in an airborne agent work environment. This level is plotted as the EhrTWA value that the detector should measure in non-aircraft work environments.
3. The single dose hazard level in a 2-10 minute exposure under which a warfighter's fighting capabilities are not measurably affected. This level is the upper boundary of the "NONE" range.
4. The single dose hazard level in a 2-10 minute exposure below which miosis, conjunctivitis, rhinorrhea, and tightness in chest occur if the population is exposed to the agent. This level is the upper boundary of the "LOW" range.
5. The single dose hazard level in a 2-10 minute exposure below which 50 percent of the population exposed show agent effects (ECt_{50}) if the warfighters do not protect their eyes and lungs. This level is the upper boundary of the "MED" range. This same dose is the lower boundary of the "HIGH" range in which dosages in a 30-50 minute exposure will affect 50 percent of the population if the warfighters do not protect their eyes, lungs, and skin.

Section 5

Joint Chemical Agent Detector Sensitivities

JCAD is a developing detector. It is being developed by the Joint Services to warn warfighters when they are in chemicals potentially used in a war. The following maximum alert response times at concentration tables are extracted from the JCAD performance specification.

Table 4. JCAD Maximum Alert Response Time at Concentration

Agent	Threshold Exposure Concentration (mg/m^3)	Threshold Exposure Response Time Max (sec)	Relative Humidity Range (%RH)	Temperature Range (°C)
VX	1 0.04 0.1	≤10 ≤90 ≤30	5 to 100	-10 to +49
GA, GB, GD & GF	1 0.1	≤10 ≤30	5 to 100	-30 to +49
HD, L, HN3	50 2	≤10 ≤120	5 to 100	-18 to +49 (for HD) -18 to +49 (for L) +15 to +49 (for HN3)
AC	2500 22	≤10 ≤60	5 to 100	-32 to +49
CK	20	≤60	5 to 100	-32 to +49

Table 5. JCAD Maximum Alert Response Time at Low Concentrations

Agent	Threshold Exposure Concentration (mg/m^3)	Threshold Exposure Response Time Max. (sec)	Relative Humidity Range (%RH)	Temperature Range (°C)
VX	0.001	≤1800	5 to 100	-10 to +49
GA, GB, GD & GF	0.001	≤1800	5 to 100	-30 to +49
HD, L, HN3	0.02	≤1800	5 to 100	+15 to +49
AC	N/A	N/A	5 to 100	-32 to +49
CK	N/A	N/A	5 to 100	-32 to +49

Table 6. JCAD Maximum Alert Response Time at Concentration

Agent	{Objective} Exposure Concentration (mg/m^3)	{Objective} Exposure Response Time Max. (sec)	Relative Humidity Range (%RH)	Temperature Range (°C)
VX	0.00001	≤900	5 to 100	-10 to +49
GA, GB, GD & GF	0.0001	≤900	5 to 100	-30 to +49
HD, L, HN3	0.003	≤900	5 to 100	+15 to +49
AC	N/A	N/A	5 to 100	-32 to +49
CK	N/A	N/A	5 to 100	-32 to +49

In Table 7, the single dose hazard levels correlate with the unclassified data from ERDC-SP-018, March 1994. Table 7 includes the correlated data from the summary of existing and recommended estimates from the ERDC-SP-018 data. Notice that the JCAD levels at the "HIGH" hazard level is half of the guideline. Notice that JCAD levels at the "NONE" hazard level is ten times lower than the ocular or nasal vapor guideline.

Table 7. JCAD Single Dose Hazard Levels, K_d

Hazard Levels	GA	GB	GD, GF	VX	HD
NONE (2-10 minute exposure in mg-min/m^3)	$\leq$0.05* (concentration is $\leq$0.005 mg/m^3 for 10 minute exposure; $\leq$0.025 mg/m^3 for 2 minute exposure)	$\leq$0.05* (concentration is $\leq$0.005 mg/m^3 for 10 minute exposure; $\leq$0.025 mg/m^3 for 2 minute exposure)	$\leq$0.02* (concentration is $\leq$0.002 mg/m^3 for 10 minute exposure; $\leq$0.01 mg/m^3 for 2 minute exposure)	$\leq$0.009* (concentration is $\leq$0.0009 mg/m^3 for 10 minute exposure; $\leq$0.0045 mg/m^3 for 2 minute exposure)	$\leq$2.5* (concentration is $\leq$0.25 mg/m^3 for 10 minute exposure; $\leq$1.25 mg/m^3 for 2 minute exposure)
LOW (Protect From Symptoms: Miosis, Conjunctivitis, Rhinorrhea, and Tightness in Chest) (2-10 minute exposure in mg-min/m^3)	>0.05 & <0.5 (For Alert: concentration is >0.005 mg/m^3 for 10 minute exposure; <0.25 mg/m^3 for 2 minute exposure)	>0.05 & <0.5 (For Alert: concentration is >0.005 mg/m^3 for 10 minute exposure; <0.25 mg/m^3 for 2 minute exposure)	>0.02 & <0.2 (For Alert: concentration is >0.002 mg/m^3 for 10 minute exposure; <0.1 mg/m^3 for 2 minute exposure)	>0.009 & <0.09 (For Alert: concentration is >0.0009 mg/m^3 for 10 minute exposure; <0.045 mg/m^3 for 2 minute exposure)	>2.5 & <25 (For Alert: concentration is >0.25 mg/m^3 for 10 minute exposure; <12.5 mg/m^3 for 2 minute exposure)
MEDIUM (Mask - Protect lungs) (2-10 minute exposure in mg-min/m^3)	$\geq$0.5 (For Alert: concentration is $\geq$0.05 mg/m^3 for 10 minute exposure; $\geq$0.25 mg/m^3 for 2 minute exposure)	$\geq$0.5 (For Alert: concentration is $\geq$0.05 mg/m^3 for 10 minute exposure; $\geq$0.25 mg/m^3 for 2 minute exposure)	$\geq$0.2 (For Alert: concentration is $\geq$0.02 mg/m^3 for 10 minute exposure; $\geq$0.1 mg/m^3 for 2 minute exposure)	$\geq$0.09 (For Alert: concentration is $\geq$0.009 mg/m^3 for 10 minute exposure; $\geq$0.045 mg/m^3 for 2 minute exposure)	$\geq$25 (For Alert: concentration is $\geq$2.5 mg/m^3 for 10 minute exposure; $\geq$12.5 mg/m^3 for 2 minute exposure)
HIGH (Suit – Protect Skin) (30-50 minute exposure in mg-min/m^3)	$\geq$1000 (For Alert: concentration is $\geq$20 mg/m^3 for 50 minute exposure; $\geq$33 mg/m^3 for 30 minute exposure)	$\geq$600 (For Alert: concentration is $\geq$12 mg/m^3 for 50 minute exposure; $\geq$20 mg/m^3 for 30 minute exposure)	$\geq$150 (For Alert: concentration is $\geq$3 mg/m^3 for 50 minute exposure; $\geq$5 mg/m^3 for 30 minute exposure)	$\geq$5 (For Alert: concentration is $\geq$0.1 mg/m^3 for 50 minute exposure; $\geq$0.17 mg/m^3 for 30 minute exposure)	$\geq$25 (For Alert: concentration is $\geq$0.5 mg/m^3 for 50 minute exposure; $\geq$0.83 mg/m^3 for 30 minute exposure)

Section 6

Advanced Chemical Agent Detector Alarm Sensitivities

The ACADA is a deployed chemical agent detector, which was procured based upon non-developmental items. The ACADA's maximum-alert response times at specified concentrations are listed in Table 8.

Table 8. ACADA Maximum Alert Response Time at Concentration

Agent	Threshold Exposure Concentration (mg/m^3)	Threshold Exposure Response Time Max (sec)	Relative Humidity Range (%RH)	Temperature Range (°C)
VX	1 0.04	≤10 ≤90	5 to 100	-10 to +49
GA, GB	1 0.1	≤10 ≤60	5 to 100	-30 to +49
GD	1 0.1	≤10 ≤30	5 to 100	-30 to +49
HD, L	50 2	≤10 ≤120	5 to 100	-18 to +49 (for HD) -18 to +49 (for L) +15 to +49 (for HN3)

Section 7

AP2C Detector (Proengin)

The AP2C is a hand-held portable unit for the monitoring and detection of G agents (GA, GB, GD, GF), VX, and HD using a hydrogen flame spectrophotometer. Table 9 includes the maximum alert response time at concentration of the AP2C detector.

Table 9. AP2C Maximum Alert Response Time at Concentration

Agent	Threshold Exposure Concentration (mg/m^3)	Threshold Exposure Response Time (sec)	Relative Humidity Range (%RH)	Operating Temperature Range (°C)
VX	3.0	2	5 to 100	-32 to +55
G (GA, GB, GD, GF)	0.010	2	5 to 100	-32 to +55
HD	0.420	2	5 to 100	-32 to +55

Section 8

Sensitivity Comparisons

Figure 1 illustrates the comparisons of the sensitivities of the detectors. For each vapor, the three lines correspond to hazard levels of "NONE," "LOW," and "MED" (medium). The JCAD is to alert on any dosages above "NONE." Thus JCAD is specified to alert at the locus of points specified as "NONE" as well as those maximum response times at the constant concentrations represented by the diamonds in the graph.

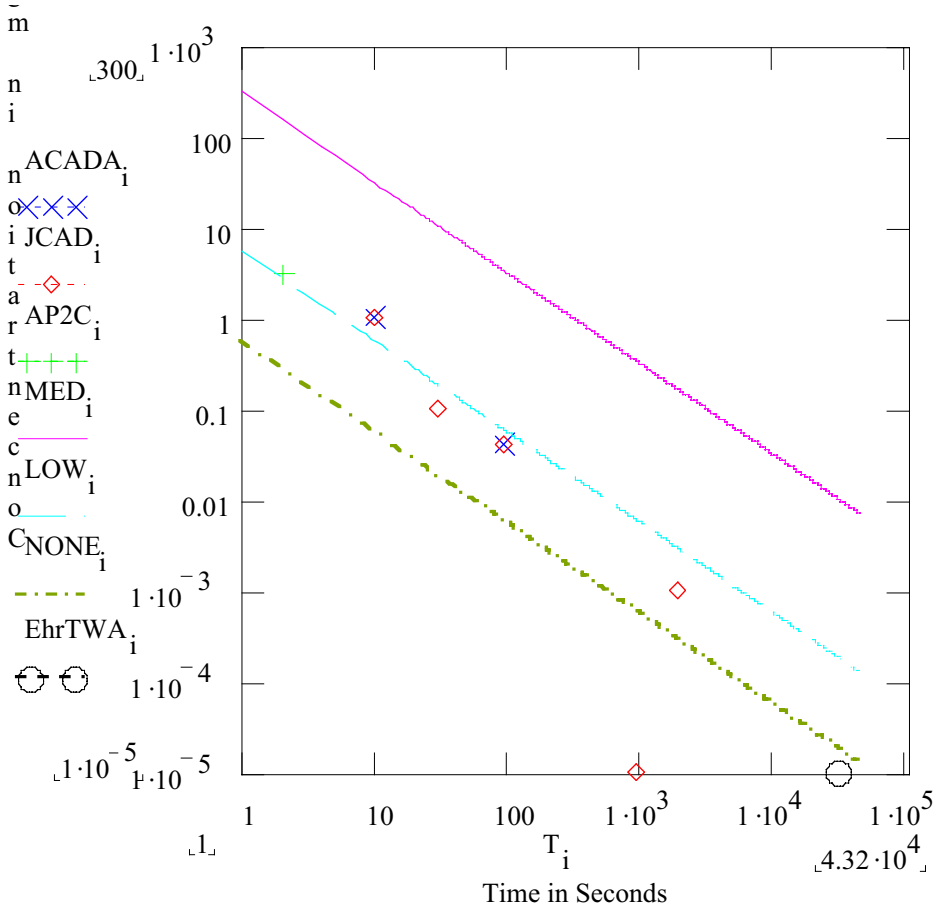


Figure 1. VX Comparisons

The VX comparisons indicate that none of the current detectors currently will verify that VX is absent at the EhrTWA level. If the JCAD is equipped with an eight-hour pre-concentrator, it might verify the EhrTWA levels. If the JCAD meets its objective

requirement, it will verify the absence of VX, because the objective requirement is set to measure the EhrTWA level in 15 minutes.

The AP2C detector, although it detects faster, has to vaporize liquid VX. The sensitivity of the AP2C to VX vapors was not reported. The vapor performance of the AP2C is based upon units conversion.

The JCAD is the only detector that is specified to have a sensitivity to assure that VX is in the "NONE" range. However, the JCAD is still in development; the actual performance has not been verified. Also, the JCAD detector has specified capability that it will measure the VX guideline concentrations for a 1-14 day time period. The graph illustrates this because the "NONE" locus of points is a constant at the VX guideline for a 1-14 day exposure.

Notice that the specification of response times at a specific concentration is of limited benefit to the user of the detector, because such a requirement is specific and does not cover the range of concentrations and time durations that might be expected. Specification of single dosage hazard levels that create a locus of specified range of behavior in the concentration and time domain is what is needed. The JCAD specification of alerts at the boundaries of the "NONE," "LOW," and "MED" hazard ranges are more generic requirements.

Thus, in the future, it is highly recommended that requirements of hazard levels be used to specify detector behavior. Also, it is highly recommended that the specification of response time at specific concentrations be eliminated. Such measurements of response time at specific concentrations should be restricted to verify the detector performance in the hazard ranges.

The specification would include a definition of the integral of the concentration over all durations **when the concentration is above zero**. This definition along with the specification of the hazard ranges would require the generation of alerts no matter what the concentration time profile. Thus, in the future, it is recommended that the performance specifications of detectors specify the single dose hazard level boundaries of the hazard ranges and use a definition of the integral of concentration to determine dosage.

Figure 2 illustrates the detector responses to GA.

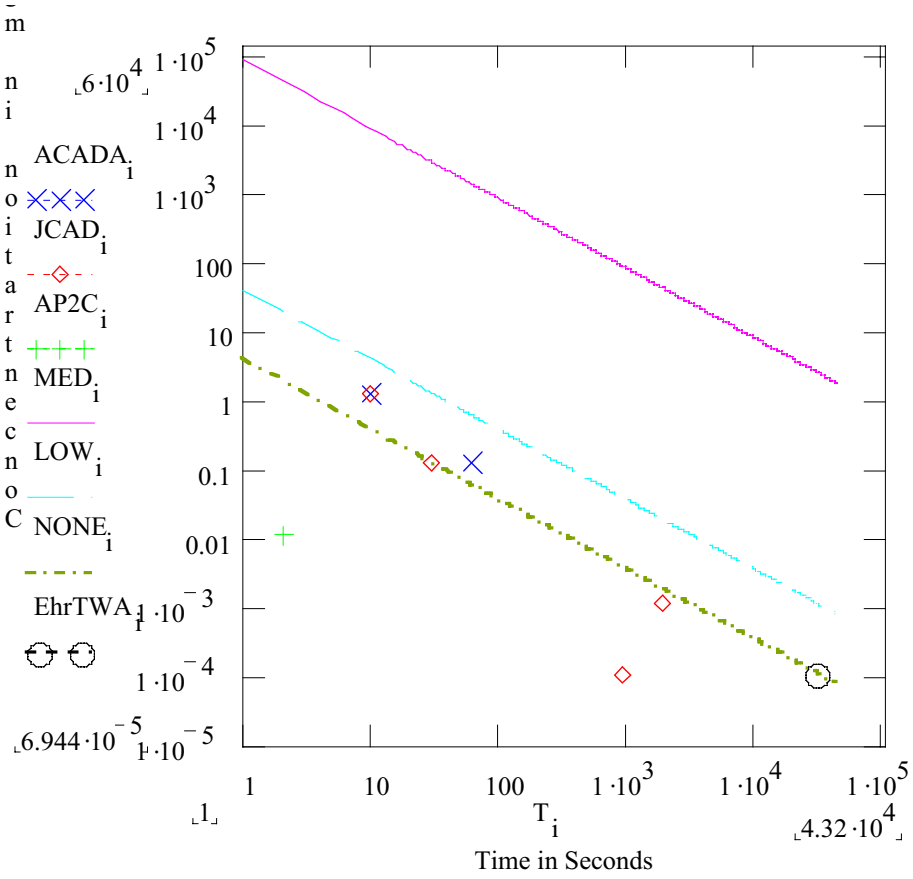


Figure 2. GA Comparisons

The GA detection specification sensitivities of the ACADA are sufficient to confirm the absence of GA over short time exposures. The JCAD specifications are also sufficient to confirm the absence of GA over longer time exposures. However, the JCAD performance has not been verified. If the JCAD was equipped with an eight-hour concentrator, then it could verify an EhrTWA level.

The AP2C detector has a high sensitivity to GA, but it is not sufficient to confirm the absence of GA at low levels over longer exposures.

None of the detectors have the capability to measure the GA guideline concentrations over a 1-14 day exposure. The 1-14 day exposure level is at the bottom of the plot. No

instrument is specified to have this level of detection. The 1-14 day exposures appear to be very low considering that the EhrTWA for workers in an agent environment is ten times higher.

If the JCAD is equipped with an eight-hour concentrator, it may verify the EhrTWA levels. If the JCAD meets its objective requirement, then JCAD will confirm the absence of GA at the EhrTWA levels in 15 minutes.

Figure 3 illustrates the detector responses to GB.

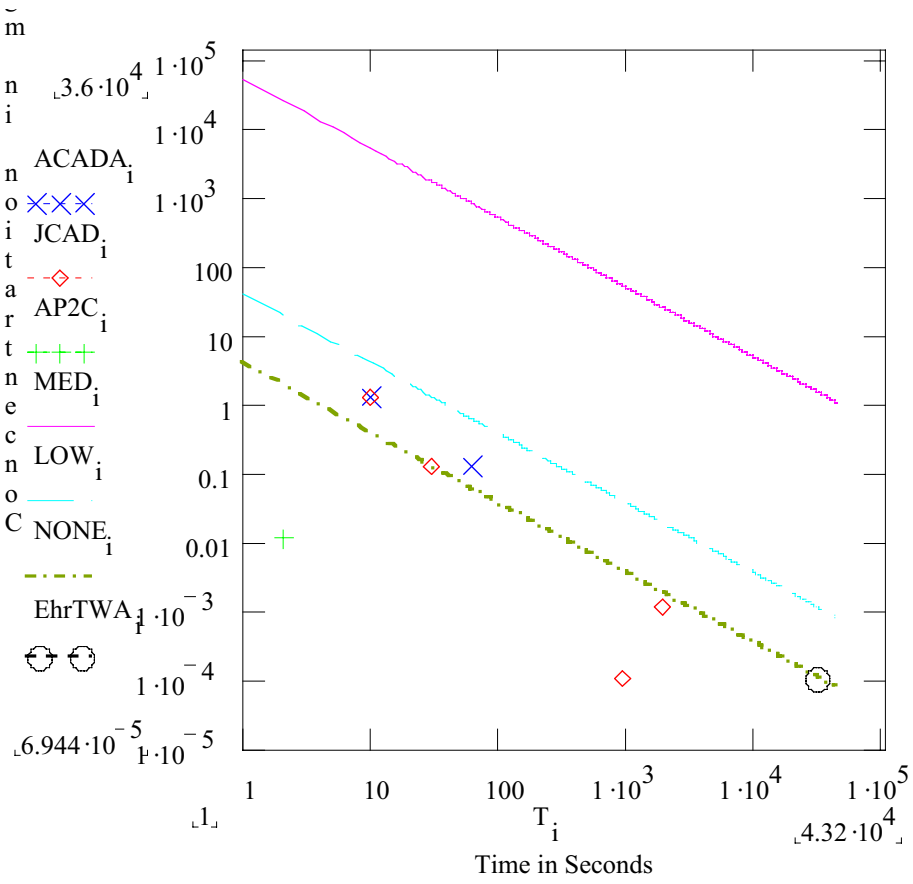


Figure 3. GB Comparisons

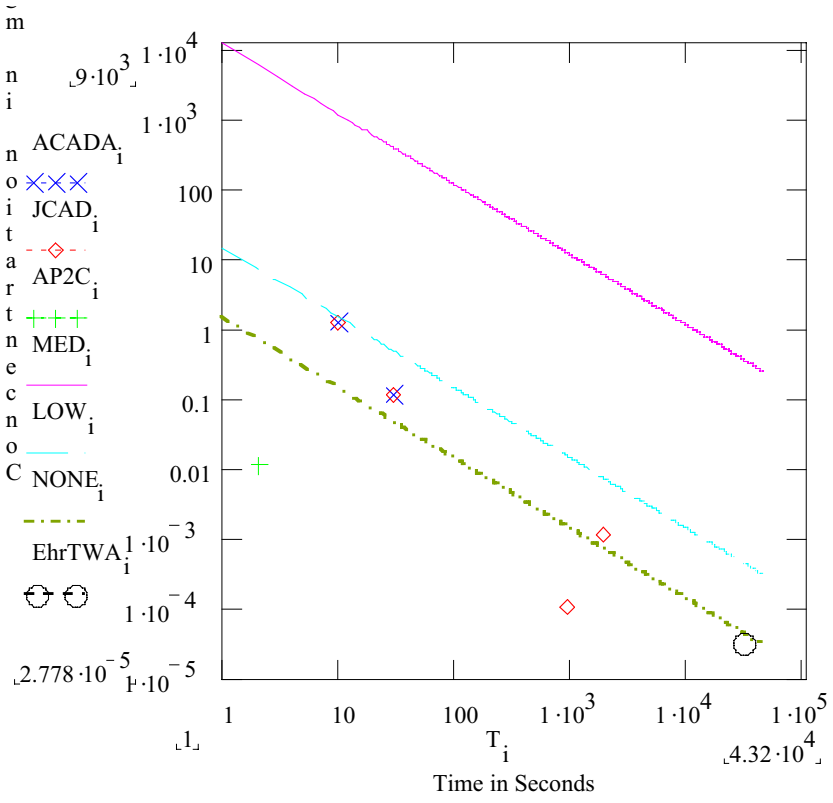
The GB detection specification sensitivities of the JCAD and ACADA are sufficient to confirm the absence of GB over short exposure times. The JCAD is specified to confirm the absence of GB at low levels over extended exposure periods (30 minutes).

The AP2C detector has a sensitivity to GB, but its sensitivity is not sufficient to confirm the absence of low levels of GB over extended exposure times.

None of the detectors will have the capability to measure the GB guideline concentrations over a 1-14 day time period. The 1-14 day exposure level is at the bottom of the plot. No instrument is specified to have this level of detection. The 1-14 day exposures appear to be very low considering that the EhrTWA for workers in an agent environment is ten times higher.

If the JCAD was equipped with an eight-hour concentrator it may verify the EhrTWA levels. The JCAD meets its objective requirement, then it will confirm the absence of GB at the EhrTWA guideline concentration in 15 minutes.

Figure 4 illustrates the detector responses to GD and GF.



GD & GF Comparisons

Figure 4. GD & GF Comparisons

The GD or GF detection specification sensitivities of the ACADA are marginally sufficient to confirm the absence of GD or GF over short exposure times. The JCAD

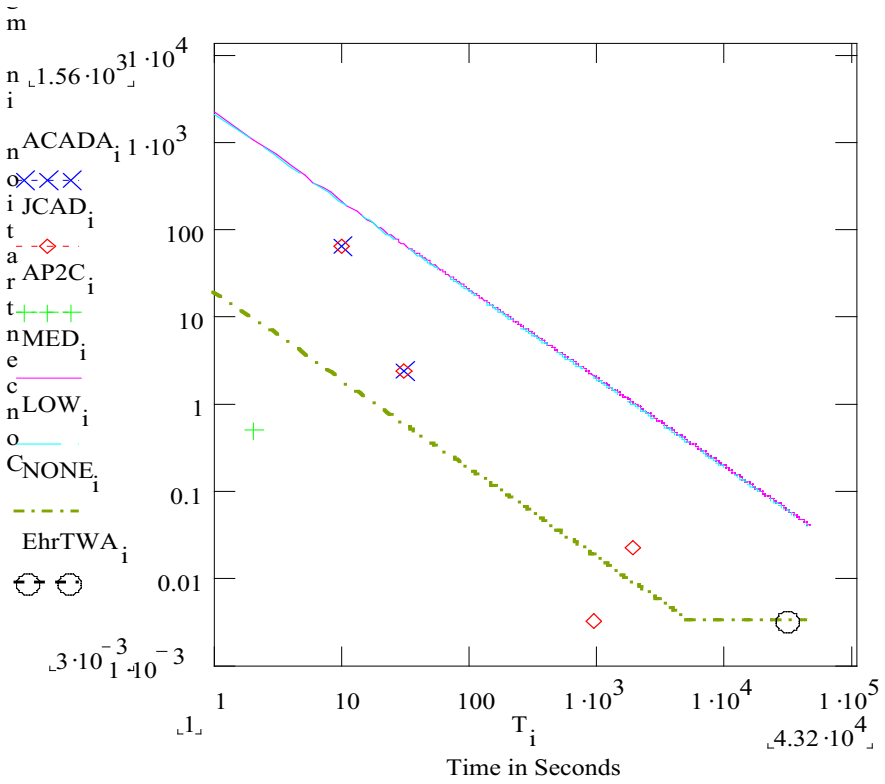
specification of the alert at the boundary of the "NONE" range is sufficient to confirm the absence of GD or GF. However, the actual performance of the JCAD is still unknown.

The AP2C detector has a sensitivity to GD and GF and can confirm the absence of GD or GF for short exposure times; but without a concentrator, it does not confirm the very low levels over longer exposure times.

None of the detectors will have the capability to measure the GD guideline concentrations over a 1-14 day time period. The 1-14 day exposure level is below the bottom of the plot (0.000003). No instrument is specified to have this level of detection. The 1-14 day exposures appear to be extremely low considering that the EhrTWA for workers in an agent environment is 33 times higher.

If the JCAD was equipped with an eight-hour concentrator, it may verify the EhrTWA levels. If the JCAD meets its objective requirement, then the JCAD will still not confirm the absence of GD and GF in minutes.

Figure 5 illustrates the detector responses to HD, L, and HN3.



HD, L, & HN3 Comparisons

Figure 5. HD, L, and HN3 Comparisons

The HD, L, and HN3 detection specification sensitivities of the ACADA are not sufficient to confirm the absence of HD, L, and HN3. The JCAD specifications are sufficient to confirm the absence of the agents along the "NONE" boundary, but the actual performance has not been verified

The AP2C detector has sensitivity to HD and can confirm the absence of HD at short exposure times, but it will not confirm the absence of HD over longer exposure times. The performance of the AP2C to detect L and HN3 is not reported in the product's specifications.

The JCAD detector will have the capability to measure the HD guideline concentrations over a 1-14 day exposure time if it meets its specified performance requirement at the "NONE" hazard level. Notice in the graph that the 1-14 day concentration is the lower limit of the "NONE" hazard range boundary.

If the JCAD was equipped with an eight-hour concentrator, it may verify the EhrTWA levels. If the JCAD meets its objective requirement, then JCAD will confirm the absence of HD, L and HN3 within 15 minutes.